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Engineering Design File

INTEC Tank Farm Closure Grout Mix Design

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PROJECT/TASK INTEC TANK FARM CLOSURE

SUBTASK FILL GROUT

TITLE INTEC TANK FARM CLOSURE GROUT MIX DESIGN

SUMMARY

The EDF summarizes the mix design for two types of fill grout. They are a cement and fly ash grout, called the pipe grout, and a cement, fly ash and sand grout, called either the tank grout or the vault grout.

The EDF includes the following sections:

INTRODUCTION
MIXTURE REQUIREMENTS
PIPE GROUT
TANK AND VAULT GROUT
CONCLUSIONS
RECOMMENDATIONS
SUMMARY OF DATA

QUALITY LEVEL ☐ 1 ☐ 2 ☒ 3 LEVEL OF RISK ☒ Low ☐ High

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AUTHOR/P. E. STAMP

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INTRODUCTION

Two types of grout mixtures are proposed for the closure of the INTEC Tank Farm. One type is a mixture of cement, fly ash, water and water reducing admixtures. For the purposes of this project it is called the pipe grout. It will be used to fill piping, small vessels or other items that require a very fluid grout.

The other type of grout is a mixture of cement, fly ash, sand, water and water reducing admixtures. For this project this type of grout mixture is called either tank grout or vault grout. The main differences between the tank grout and the vault grout are the required strength and the slump or flowability. The vault grout is required to flow around at least half the circumference of the existing 50 ft diameter tanks.

The following sections discuss the mix design for pipe, tank and vault grouts. The discussion is based on design mix tests and placements of grout for both the WCF RCRA Closure and the conceptual design for closure of the INTEC Tank Farm.

MIXTURE REQUIREMENTS

The grout mixtures must flow easily since placement locations and methods are limited. This requirement has been measured in the past using standard concrete slump tests (ASTM C 143). At least 9 in. of slump was required for all the mixtures and the pipe grout required slumps in excess of 11 in.

The grout mixtures may also be required to harden to a minimum compressive strength. This minimum has yet to be determined but is expected to be at least 500 psi. The vault grout must have a minimum compressive strength of 3,000 if it is used to cover the tanks without completely filling the tanks.

The flowability or fluidity of the mixtures is the main requirement for the grouts. The tank grout must also be able to move the tank waste liquids and to some extent solids to locations where the wastes can more easily be removed from the tanks. For this reason, the tank grout needs to be less fluid than the other grout mixtures. Adjusting the amount of water present in the mixtures appears to be easiest way to obtain the desired fluidity.

Other qualities that are desirable for the grout mixtures include:

- no bleed water or as low amount of bleed water as is achievable
- low shrinkage and limited shrinkage cracking
- low heat generation, since high temperatures will cause cracking and other undesirable affects

Cracks increase the chance for materials to move into or out of the hardened grout. The quantity and their size of cracks should therefore be as small as possible.

The cost of the mixture is also a consideration but was not a primary factor in the design of the mixtures as presented herein.

The proposed mixtures meet the requirements by:

- using water reducers to increase slump and flowability
- using relatively low quantities of cement
- using fly ash as a replacement for cement
- limiting the amount of water in the mix to the extent possible

PIPE GROUT

The basic mix design for a cubic yard of the pipe grout is as follows:

Cement	680 lbs	Type I & II cement
Pozzolan Class F	1,600 lbs	Fly ash
Water	Up to 800 lbs	(96 gallons)
Medium-range water reducer	32 oz	
High-range water reducer	64 oz	

The latest tests for the pipe grout used 91 gallons of water per cubic yard. This reduced the shrinkage and bleed water associated with the pipe grout mix and increased the compressive strength. The 28 day and 56 day compressive strengths for the pipe grout mixture with 91 gallons of water were 3,360 psi and 4,680 psi respectively. The lowest 28 day test compressive strength for the pipe grout mixture tests was 2,400 psi. These strengths are much higher than any known strength requirements for this grout.

The pipe grout will readily flow through pipes as small as 1/2 inch in nominal diameter. It has been pumped through holes as small as 1/8 inch in diameter. However, if the pipe grout is pumped for an extended period or pumping stops and is then restarted the small diameter holes or pipe tend to plug. The slump of this grout as tested by ASTM C 143 is in excess of 11.5 inches. This test procedure is not very accurate for grouts that are this fluid. Future flowability tests should use a different test procedure.

For larger pipes it may be possible to reduce the water content of this mixture and thus reduce the shrinkage and bleed water associated with the high water content. If the water is decreased the dry materials will need to be increased maintain the yield volume at a cubic yard.

Bleed water amounts from past tests of this mixture were low. The maximum amounts were observed when 55 gallon barrels were filled with the grout mixture and then covered. The largest quantity of water observed on the top of the grout was a depth of approximately 1/4 in. in a 55 gallon barrel.

TANK AND VAULT GROUT

The tank and vault grouts have different purposes but the same basic mixture is currently proposed for both uses. The difference is mainly in the flowability of the grout mixture. The flowability has been measured in the past using a standard concrete slump test (ASTM C 143). The minimum slump for the

vault grout using ASM C 143 is 11 inches. The tank grout slump using ASTM C 143 will vary from about 10 inches to 11 inches depending on the requirements of a placement.

The vault grout is required to have a compressive strength of at least 3,000 psi. It also must flow readily around the circumference of the liquid waste storage tank.

The tank grout will be used to minimize the waste left within the tanks. A minimum compressive strength for the tank grout has not been set. It also provides the weight necessary to resist buoyant forces from the first vault grout placement.

The basic mix design tank and vault grout is as follows:

Cement	320 lbs	Type I & II cement
Pozzolan Class F	640 lbs	Fly ash
Fine aggregate	2,200 lbs	Sand
Water	Up to 433 lbs	(52 gallons)
Medium-range water reducer	64 oz	
High-range water reducer	96 oz	

The grout placement tests associated with the first stage of the conceptual design for closure of the INTEC Tank Farm showed that that grout with a slump of more than 11 inches will flow halfway around the circumference of a 50 ft diameter tank. The difference in elevation between the grout at the placement location and the opposite side of the tank for one of the tests was about 8 inches.

The test grout used less water than the 52 gallons per cubic yard shown above. The amount of water ranged from a low of 45 gallons to a high of 50 gallons. The water to cementious materials ratio ranged from 0.40 to 0.43. The water to cementious material ratio for the mix with 52 gallons of water is 0.45.

High and medium range water reducing admixtures are included in the mixes to enhance the workability of the grout mixtures without increasing the water content. Additional water reduces strength and density, increases shrinkage and shrinkage cracking, increases bleed water and increases permeability of the cured grout. Therefore the water content of the grout mixtures needs to be minimized.

The materials used in the grout mixtures were used because they are readily available in the intermountain west. Most ready-mix suppliers in the region near the INEEL are also set up to supply concrete or grout mixtures similar to the proposed grout mixtures. Other materials, such as finely ground blast furnace slag, were considered for the grout mixtures. However, they were not used since they are not readily available in the region near the INEEL.

The testing to date indicates that all mixtures are flowable and will achieve 28 day compressive strengths of at least 2,000 psi. Because of the high fly ash content of the mixtures, they continue to gain significant strength for a longer time period than is normal for typical construction grouts.

56 day compressive strengths are approximately 1,000 psi stronger than the 28 day compressive strengths.

Additional data on flowability, bleed water, shrinkage and temperature as well as strength are available for the proposed grout mixtures in at least two unpublished reports. The compressive strength data is filed at the INEEL Material Test Lab located at the Central Facilities Area (CFA).

CONCLUSIONS

All of the test batches appeared to perform in a satisfactory manner regarding bleed water amounts and shrinkage.

Flowability was acceptable when concrete slumps were within the ranges previously mentioned.

Compressive strengths exceeded requirements, in some cases by substantial amounts. See the attached graph.

RECOMMENDATIONS

Future studies are recommended for the grout mixtures, particularly the tank grout. These studies may include additional strength tests, flow tests, sensitivity of the grout mixture to different environmental conditions, tests to determine the pumping characteristics for the grout, tests that indicate the long term durability of the cured grout, and other tests related to the proposed grout placement equipment or systems. The strength tests may include grout cylinders cured under conditions more closely matching actual conditions inside the tanks.

A more sensitive test for flowability of the grout mixture is necessary. ASTM C 143 does not provide enough sensitivity since the required slumps for the grout are at least 9 inches and for most proposed placements are in excess of 11 inches. The standard could be a cone flow test, a measurement of the diameter of the grout puddle obtain from a slump cone test, a measurement of difference in elevation of grout in a trough or variations of these.

ENGINEERING DESIGN FILE

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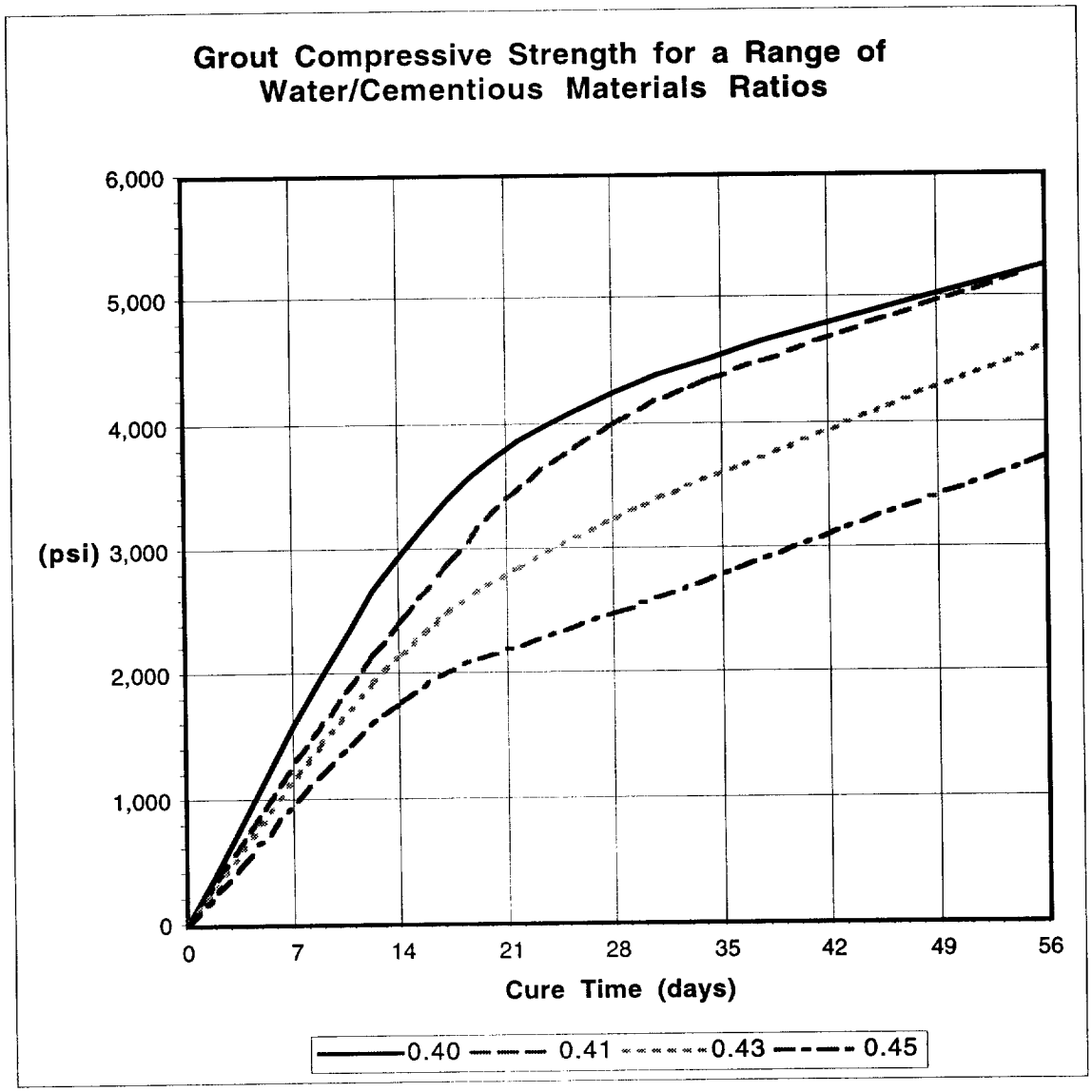
Subtask	GROUT MIX DESIGN	EDF No.	EDF-1464

SUMMARY OF DATA

The following graph summarizes the strength data obtained for the tank and vault grouts mixtures from the most recent tests.



Concrete Mix Design Spreadsheet

Tank/Vault Grout (52 gallons per cubic yard)

Material	Specific Gravity	Unit Weight (lbs/cu ft)	Quantities				
			Weight (lbs)	Weight %	Volume (cu ft)	Water Volume (gallons)	w/c ratios
Water	1.00	62.4	433	12.0%	6.9	52	
Cement (Type I-II)	3.15	196.6	320	8.9%	1.6	w/c =	1.35
Fly Ash	2.23	139.2	640	17.8%	4.6	w/(c+ash) =	0.45
Sand	2.48	154.8	2,200	61.1%	14.2	c/(c+ash) =	0.33
Gravel	2.63	164.1	0	0.0%	0.0		
Mid-range	1.00	62.4	4.0	0.1%	0.1	oz/cwt(c+ash) =	6.7
High-range	1.00	62.4	6.0	0.2%	0.1	oz/cwt(c+ash) =	10.0
Retarder	1.00	62.4	0.0	0.0%	0.0	oz/cwt(c) =	0.0
Totals		**130.8**	**3,603**	**100%**	**27.5**		

Tank/Vault Grout (50 gallons per cubic yard)

Material	Specific Gravity	Unit Weight (lbs/cu ft)	Quantities				
			Weight (lbs)	Weight %	Volume (cu ft)	Water Volume (gallons)	w/c ratios
Water	1.00	62.4	417	11.6%	6.7	50	
Cement (Type I-II)	3.15	196.6	320	8.9%	1.6	w/c =	1.30
Fly Ash	2.23	139.2	640	17.8%	4.6	w/(c+ash) =	0.43
Sand	2.48	154.8	2,200	61.3%	14.2	c/(c+ash) =	0.33
Gravel	2.63	164.1	0	0.0%	0.0		
Mid-range	1.00	62.4	4.0	0.1%	0.1	oz/cwt(c+ash) =	6.7
High-range	1.00	62.4	6.0	0.2%	0.1	oz/cwt(c+ash) =	10.0
Retarder	1.00	62.4	0.0	0.0%	0.0	oz/cwt(c) =	0.0
Totals		**131.5**	**3,587**	**100%**	**27.3**		

Tank/Vault Grout (48 gallons per cubic yard)

Material	Specific Gravity	Unit Weight (lbs/cu ft)	Quantities				
			Weight (lbs)	Weight %	Volume (cu ft)	Water Volume (gallons)	w/c ratios
Water	1.00	62.4	400	11.2%	6.4	48	
Cement (Type I-II)	3.15	196.6	320	9.0%	1.6	w/c =	1.25
Fly Ash	2.23	139.2	640	17.9%	4.6	w/(c+ash) =	0.42
Sand	2.48	154.8	2,200	61.6%	14.2	c/(c+ash) =	0.33
Gravel	2.63	164.1	0	0.0%	0.0		
Mid-range	1.00	62.4	4.0	0.1%	0.1	oz/cwt(c+ash) =	6.7
High-range	1.00	62.4	6.0	0.2%	0.1	oz/cwt(c+ash) =	10.0
Retarder	1.00	62.4	0.0	0.0%	0.0	oz/cwt(c) =	0.0
Totals		**132.2**	**3,570**	**100%**	**27.0**		

Tank/Vault Grout (45 gallons per cubic yard)

Material	Specific Gravity	Unit Weight (lbs/cu ft)	Quantities				
			Weight (lbs)	Weight %	Volume (cu ft)	Water Volume (gallons)	w/c ratios
Water	1.00	62.4	375	10.3%	6.0	45	
Cement (Type I-II)	3.15	196.6	320	8.8%	1.6	w/c =	1.17
Fly Ash	2.23	139.2	640	17.6%	4.6	w/(c+ash) =	0.39
Sand	2.48	154.8	2,300	63.1%	14.9	c/(c+ash) =	0.33
Gravel	2.63	164.1	0	0.0%	0.0		
Mid-range	1.00	62.4	4.0	0.1%	0.1	oz/cwt(c+ash) =	6.7
High-range	1.00	62.4	6.0	0.2%	0.1	oz/cwt(c+ash) =	10.0
Retarder	1.00	62.4	0.0	0.0%	0.0	oz/cwt(c) =	0.0
Totals		**133.7**	**3,645**	**100%**	**27.3**		